Transportation Identification

Using a 1:50,000 scale map of the area, register the mylar to the base map and annotate the marginal information.

**Roads**

**Step 1.** Use the legend of the base map to locate the road classification and type of route. The route identification numbers will be located astride each road inside the route symbol. In some areas where the local government does not assign the roads identification (ID) numbers, you will need to assign arbitrary numbers.

**Step 2.** Trace all road segments onto the overlay using the proper symbol for each road classification. While tracing each road, look for points where either the classification or ID numbers change. Place a mute symbol at each point of change and annotate the classification and ID numbers as needed. As you trace each road, consider that interstate and federal routes do not change when crossing state or county boundaries. State roads change both classification and ID numbers when crossing state boundaries, and county roads either change classification or are terminated when crossing county or state boundaries. See Figure 4-1.

**Step 3.** Carefully study the base map legend and compare it the 1:50,000 (TTADB) and 1:250,000 (PTADB) product specifications to determine which factor overlay symbol to use for each map symbol.

**Step 4.** The surface material of each road is located in the legend across from the appropriate classification symbol. Determine which base map symbol is used in making the factor overlay and record the feature for each symbol in the legend of the factor overlay.

**Step 5.** Determine the width of the traveled way. Your accuracy in this will vary with the topographic map available. The FRG, USSR, and other European maps indicate the width in meters, but US maps indicate it by the number of lanes or a range of widths. Each road segment between intersections is assigned a width.
Note: Only a representative pattern of major through routes and secondary roads are annotated.

Figure 4-1. Transportation legend (highways)

value, with that number placed parallel to the road segment. Table 4-1 below indicates lane widths currently shown on US military maps.

<table>
<thead>
<tr>
<th>Trail</th>
<th>Meters</th>
<th>Feet</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trail</td>
<td>Less than 1.5</td>
<td>Less than 5</td>
</tr>
<tr>
<td>Track</td>
<td>At least 1.5 but less than 2.5</td>
<td>At least 5 but less than 8</td>
</tr>
<tr>
<td>One lane</td>
<td>At least 2.5 but less than 5.5</td>
<td>At least 8 but less than 18</td>
</tr>
<tr>
<td>Two lanes</td>
<td>At least 5.5 but less than 8.2</td>
<td>At least 18 but less than 28</td>
</tr>
<tr>
<td>More than two lanes</td>
<td>At least 8.2</td>
<td>At least 28</td>
</tr>
</tbody>
</table>

Table 4-1. Lane widths currently shown on US military maps

Follow each route and determine the number of lanes and widths. Convert the lane width to meters to indicate the minimum width of the traveled way. Lightly record this value along the road outlined on the overlay.

Always use a decimal point when recording the road width, for example, 5 meters = 5.0 meters. Assign each road segment between intersections a width value, then place that number on the road segment. Note every point at which a change in width occurs and place a segment symbol at each of those points.

4-2
When dual routes occur, indicate the width of each route. If the source map gives only the overall width, assume each side has half the width.

**Step 6.** Depict gradient or percent of slope on the overlay when it exceeds 7 percent. The flat end of the first arrowhead is at the bottom of the grade, and the point of the last arrowhead is at the top. Measure the gradient from the topographic base map.

To determine percent of slope, measure the change in elevation (vertical distance or rise) and divide it by the horizontal distance (run), then multiply by 100.

\[
\text{percent slope} = \frac{\text{Rise} \times 100}{\text{Run}}
\]

**Step 7.** Show a constriction when the road narrows to less than 4 meters. Indicate the width measurement adjacent to the arrowhead symbol.

**Step 8.** Record all sharp curves with a radius of 30 meters or less.

**Step 9.** Depict all features that are currently under construction with the circled symbol UC.

**Step 10.** UTM coordinates are given for key reference points and features. See FM 21-26, which discusses map-reading instructions.

**Bridges, Tunnels, Galleries, and Snowsheds**

**Step 1.** All bridges are not usually drawn to their true scale on US military maps. Bridges less than 100 meters long are shown as point features, and bridges greater than or equal to 100 meters are symbolized by wing ticks. The only bridges not shown are located on roads that are not depicted. Plot the length between wing ticks to scale; minimum length between wing ticks is 2.0 millimeters. Point features are less than or equal to 2.0 millimeters. Draw all other features to scale.

To determine the true length of a structure, use a microcomparator and measure the feature. Multiply the length of the feature as measured by the microcomparator using the map scale to get the feature length. Record all structure lengths in the data table.

**Step 2.** Determine structure width. Using the road symbol, establish the width of all structures of one or more lanes directly from the map. For tunnels and fords, use only half the width indicated by the symbol, unless other information sources indicate differently. This width reduction is necessary because some structures are built with only one lane to reduce the cost of construction. See Figure 4-2.

![Tunnel Data](image)

Figure 4-2. Transporation legend (tunnels)
Step 3. Determine the depth of overburden. The depth of the tunnel overburden has tactical significance due to the ability to render road or railroad routes impassable to tactical units, especially if bypass capabilities are restrictive. Tunnel overburden is the material, such as soil and rock, that is directly over the tunnel structure. See Figure 4-3. You can obtain true depth determination of the tunnel overburden only by ground measurements or from DA Form 1250, Tunnel Reconnaissance Report. See Figure 4-4. You can estimate depth using aerial photography or mensuration techniques. The least effective method is to use contour lines on a topographic map. If using a topographic map, the maximum depth of the material (for example, soil or rock) laying directly over a tunnel can be estimated.

a. Determine the elevation of the road surface where it intersects with each tunnel portal. Select the portal with the lowest elevation.

b. Locate the highest contour line that passes directly over the tunnel symbol and determine its elevation.

c. Subtract the elevation determined in Step 3a from the elevation determined in Step 3b. This number is an estimated depth of the tunnel overburden. Record it on DA Form 1250 as an estimate.

Step 4. Determine bypass conditions of bridges. You can determine bypass conditions from a detailed study of the total area extending a distance of 2 kilometers on either side of the bridge. Look for the following factors when evaluating bypass conditions: steepness of bank slopes, depth of water, denseness of vegetation, roughness of surface, presence of boulders or approaches, and wet or soft ground.

4-4
**TUNNEL RECONNAISSANCE REPORT**

<table>
<thead>
<tr>
<th>TO: (Headquarters ordering reconnaissance)</th>
<th>ATTN:</th>
<th>FROM: (Name, grade and unit of reconnaissance officer)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CDR 84th Engr BN</td>
<td>S2</td>
<td>John H. Doe, 1Lt, Co. B 84th Engr</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>1. HIGHWAY</th>
<th>2. FROM (Initial Point)</th>
<th>3. TO (Terminal Point)</th>
<th>4. DATE/TIME (At signature)</th>
</tr>
</thead>
<tbody>
<tr>
<td>MO 83</td>
<td>DL 67332</td>
<td>DL 678339</td>
<td>18 16:30 Nov</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>5. MAP SERIES/NA</th>
<th>6. SHEET NUMBER</th>
<th>7. GRID REFERENCE</th>
<th>8. TUNNEL NUMBER</th>
</tr>
</thead>
<tbody>
<tr>
<td>V734</td>
<td>5133I</td>
<td>1:50,000</td>
<td>I-1</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>9. LOCATION FROM NEAREST TOWN</th>
<th>10. TYPE (Subterranean, Rock, Soil)</th>
</tr>
</thead>
<tbody>
<tr>
<td>N/A</td>
<td>Rock</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>11. NAME (Mountain or Water feature)</th>
<th>12. LENGTH</th>
<th>13. NUMBER OF TRACKS</th>
<th>14. ROADWAY WIDTH</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blue Springs</td>
<td>135m</td>
<td>N/A</td>
<td>8.5m</td>
</tr>
</tbody>
</table>

15. CLEARANCE: Vertical 7.3m Horizontal 9.1m
16. GRADE (Percent): 4.2%
17. ALIGNMENT (Straight or radius of curve): Straight
18. LINING (Material): Stone
19. PORTALS (Material): Concrete
20. VENTILATION (Type): Natural

21. DRAINAGE: Adequate

22. CHAMBERED FOR DEMOLITION: [ ] YES [ ] NO
23. COMPLETED (Year): 1921
24. CONDITION (Check appropriate box):
   [ ] EXCELLENT [ ] GOOD [ ] FAIR [ ] POOR

25. BYPASSABILITY: Difficult

26. ALTERNATE CROSSING: MO 671 to MO 83

27. APPROACHES: Good 2%

28. IN-TUNNEL RESTRICTIONS: None

29. GEOLOGIC DATA: Limestone

**Figure 4-4. Sample tunnel reconnaissance report**
Identify each bypass as easy (E), difficult (D), or impossible (I) on the line extending from the NATO bridge symbol to the map location. Easy obstacles can be crossed within the immediate vicinity of the bridge by a US 2 1/2-ton 6 x 6 truck (or NATO equivalent) without improving the bypass. Difficult obstacles can be crossed within the immediate vicinity of the bridge, but some work will be necessary to prepare the bypass. Impossible obstacles can only be crossed by repairing the existing bridge or constructing a new bridge. See Figure 4-5.

**Fords**

A ford is a location in a water barrier where the physical characteristics of the current, bottom, and approaches permit the passage of personnel and/or vehicles.

Estimate the crossing length of a ford from the map symbol by measuring the distance between the stream margins. Streams that show only one line are 25 meters or less in width and cannot be used as fords. See Figure 4-6.
PART TWO  Analysis Procedures  FM 5-33

**FERRIES**

Step 1. Determine travel distance. You cannot determine the actual distance of ferry travel by analyzing the map, because the route indicated on the map is usually an approximation. When ferry terminals are directly opposite each other, you can use the width of the river as an approximate travel distance. If the terminals are located on different maps, determine the straight line open water distance and record it on DA Form 1252, Ferry Reconnaissance Report. When you approximate distances, note this fact adjacent to the length in the reconnaissance report.

Step 2. Sketch the dimensional plan of terminals. US military maps often indicate the plan view of large ferry terminals. Sketch the dimensions of wharves, buildings, and parking lots in plan view on the ferry reconnaissance report indicating all true distances.

**AIRFIELDS**

Step 1. Trace over the runway to show which direction the runway is oriented. At the end of each runway, indicate its azimuth to the nearest 10 degrees by dropping the zero from the numerical value and deriving a one- or two-digit number. For example, if the azimuth is 260 degrees, the number recorded on the runway is 26. Record the azimuth on the overlay.

Step 2. Measure the length and width of the runway using the map scale. If the runways are not wide enough to permit this procedure, you may place the numerals immediately adjacent to the runway. The runway length measurement should exclude the overrun area. Add the information as to whether the runway is paved (P) or unpaved (U), if you know it. See Figure 4-7.

**HELIPORTS**

Heliports with runways offer evidence that they are designed for heavier wheeled cargo or passenger helicopters, while helipads accommodate rotary wing aircraft.

---

**Figure 4-7. Transportation legend (Airfields)**

\[
\text{Estimated Ford Length} = \frac{\text{Map Scale} \times \text{Ford Length}}{1,000}
\]

Divide estimated length by 1,000 to change the length to meters.
that do not require a takeoff ground run to become airborne. Label the azimuths of heliports that have distinct runway orientation. Record the dimensions for width and length using the map scale and the procedure shown above in Step 2 of Airfields.

**Railroads**

Step 1. Determine the correct category from the map legend for railroads and select the proper symbol for each type. Then draw the railroad symbol on the overlay for each railroad in the same category. Follow the railroad throughout its length on the map, looking for points at which either the category or the ID number changes. Position the symbols to conform with mapping standards. See Figure 4-8.

Step 2. Examine the map and legend and determine the track route, gages, and locations of bridges, facilities, and crossings. Note tunnels and spurs as well as suspected crossings.

Step 3. Start tracing the alignment of the railroad across the entire sheet. Continue this process until you have traced all railroad tracks onto the overlay. Where the tracks intersect with a built-up area, continue tracing the railroad through the area. Mark lightly all pertinent features such as bridges, tunnels, and crossings. If the sheets show a track siding, trace it to its end. Measure the length of the siding in meters and record it on the overlay. If the siding has a building or facility indicated or suspected, trace and annotate its location. Certain facilities may sometimes provide electrical tracks for their privately-owned siding or spur. The
track may also become multiple along the siding or spur, if so, you must note this on the overlay.

**Step 4.** Whenever the route crosses a stream or creek, note the possibility of a culvert on the overlay. You must also identify all road or highway crossings on the overlay, using the proper symbol.

**Step 5.** Rarely will a railroad grade exceed 3 percent. If the contour interval suggests a greater gradient, note this on the overlay. A slope overlay may be available with the surface configuration overlays, if previously compiled.

**Step 6.** Locate and trace all railroad cut and fill areas. Much of this data will be deleted from the final overlay. Cuts are potential railroad traffic interdiction sites because of the possibility of slides induced by demolition of steep side slopes.

**Step 7.** Railroad bridges are normally symbolized on topographic maps. Unfortunately, the type of bridge or construction material is seldom stated. Locate all highway bridges that intersect the railroad route, as well as all railroad-carrying bridges. Draw the bridge symbol on the overlay adjacent to the site. Measure the bridge length in meters and note. This will be relevant bridge data for DA Form 1249, Bridge Reconnaissance Report.

**Step 8.** Identify the railroad structures. The map legend or map area may have printed data labeling various railroad facilities such as water towers and switching pits.

**PHOTO ANALYSIS OF TRANSPORTATION**

**Oblique Aerial Photography**

The scale of oblique photography is difficult to determine, because it constantly varies from the foreground to the background of the photo. If vertical aerial photography is not available and you must use oblique photography to obtain the necessary data, consult the appropriate references.

**Aerial Photographic Measurements**

**Step 1.** Determine horizontal measurements. With a magnifier, carefully determine the location of the traveled way of the bridge. Determine the distance between the curbs of the traveled way with the microcomparator, and take the measurement using the metric scale. Multiply the image measurement by the photo scale to determine the true measurement. Record this value on the bridge cross-sectional sketch on DA Form 1249. Determine the length of bridge number 1 by first locating, under stereo viewing conditions, the abutments at each end of the bridge. With the microcomparator, measure the distance between the abutments. Multiply this image distance by the photo scale and record it at the proper place on your sketch. If the bridge is composed of a number of spans, record them on the sketch and in the Bridge Reconnaissance Report.

**Step 2.** Determine vertical measurements. Obtain vertical measurements, such as the vertical clearance of the bridge and the under-bridge clearance, from stereo aerial photography by using a parallax wedge or bar. Measurements made with these instruments are more accurate than those obtained from a map, but they are
not as accurate as those obtained from on-site measurements or from as-built drawings. Record the distance on the cross-section sketch on the Bridge Reconnaissance Report.

**Step 3.** Determine under-bridge clearance. Determine the under-bridge clearance (using the same method) by measuring the difference in elevation between the bridge deck and the surface of the feature passing beneath the bridge. Since the bridge substructure will not be visible to you, you will need to estimate the height of the substructure and subtract it from the computed under-bridge clearance distance. Record the under-bridge clearance distance on the sketch on the Bridge Reconnaissance Report.

**Step 4.** Determine height. Use the parallax bar to determine height. Orient photos and secure them with tape.

**Surface Materials and Conditions**

**Step 1.** Estimate surface materials. Figure 4-9 lists the general air photo characteristics of road surface materials. Compare the photo appearance with the table, and estimate the surface material during the map analysis. Consider the route category when the type of material is not readily apparent. For example, national routes are usually concrete or bitumen, while country roads are often gravel.

**Step 2.** Estimate surface conditions. Surface condition is difficult to estimate except from very large-scale photography. Look for evidence of frequent patching, checks, broken edges, potholes, ruts, and frost or heat heaving.

**Step 3.** Determine surface materials of medians and shoulders. These materials may be bare ground, grass, trees, shrubs, gravel, bitumen, or concrete. In some instances, the median may be only a wall or barrier and will be difficult to detect. Therefore, use the largest photos and the highest practical magnification available.

**Bridges**

**Step 1.** Identify structure features, using oblique photography. Because they provide an side view of the structure, oblique photos are the best some to determine construction type, material, length, overhead and under-bridge clearances, number and type of span, and length of individual spans. Measurement is dependent on careful, accurate determination of the scale. When practical, make duplicate measurements on vertical photography and average the results.

**Step 2.** Measure bridge features using vertical photography. Measurements on vertical photos are usually more accurate than similar measurements made on oblique photographs, but vertical photos do not provide the side view so useful in determining the type of construction. A definite shadow of the bridge often provides much of the same information available from oblique coverage. When no shadow of the bridge exists, examine the surrounding vertical photographs and look for an image of the bridge that falls near the edge of the photograph. Images near the edge of vertical photos are often displaced or tilted so that the side of the object is visible.

**Step 3.** Determine the military load class. You cannot determine the military load class directly from aerial photography, but you can roughly estimate it from vehicles that were using the bridge at the time the photo was taken. Examine the
<table>
<thead>
<tr>
<th>FILM TYPE</th>
<th>CONCRETE</th>
<th>PAVING STONE</th>
<th>BITUMEN</th>
<th>GRAVEL</th>
<th>SOIL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Panchromatic</td>
<td>• Center line present</td>
<td>• Center line present</td>
<td>• Center line present</td>
<td>• No center line</td>
<td>• No center line</td>
</tr>
<tr>
<td></td>
<td>• Definite margins</td>
<td>• Light to dark tone depending on materials</td>
<td>• Indefinite margins</td>
<td>• Indefinite margins</td>
<td>• Indefinite margins</td>
</tr>
<tr>
<td></td>
<td>• Light tone</td>
<td>• Pattern of blocks may be detectable</td>
<td>• Dark tone</td>
<td>• Light to dark gray tone</td>
<td>• Tone dependent on soil color</td>
</tr>
<tr>
<td>Black and white infrared</td>
<td>• Center line present</td>
<td>• Center line present</td>
<td>• Center line present</td>
<td>• No center line</td>
<td>• No center line</td>
</tr>
<tr>
<td></td>
<td>• Definite margins</td>
<td>• Light to dark tone depending on material</td>
<td>• Indefinite margins</td>
<td>• Indefinite margins</td>
<td>• Indefinite margins</td>
</tr>
<tr>
<td></td>
<td>• Light tone</td>
<td>• Pattern of blocks may be detectable</td>
<td>• Dark tone</td>
<td>• Light to dark gray tone</td>
<td>• Tone dependent on soil color</td>
</tr>
<tr>
<td>Color</td>
<td>• Center line present</td>
<td>• Center line present</td>
<td>• Center line present</td>
<td>• No center line</td>
<td>• No center line</td>
</tr>
<tr>
<td></td>
<td>• Definite margins</td>
<td>• Light to dark tone depending on material</td>
<td>• Indefinite margins</td>
<td>• Indefinite margins</td>
<td>• Indefinite margins</td>
</tr>
<tr>
<td></td>
<td>• Light tone</td>
<td>• Pattern of blocks may be detectable</td>
<td>• Dark tone</td>
<td>• Light to dark gray tone</td>
<td>• Tone dependent on soil color</td>
</tr>
<tr>
<td>Color infrared</td>
<td>• Center line present</td>
<td>• Center line present</td>
<td>• Center line present</td>
<td>• No center line</td>
<td>• No center line</td>
</tr>
<tr>
<td></td>
<td>• Definite margins</td>
<td>• Light to dark tone depending on material</td>
<td>• Indefinite margins</td>
<td>• Indefinite margins</td>
<td>• Indefinite margins</td>
</tr>
<tr>
<td></td>
<td>• Light tone</td>
<td>• Pattern of blocks may be detectable</td>
<td>• Dark tone</td>
<td>• Light to dark gray tone</td>
<td>• Tone dependent on soil color</td>
</tr>
</tbody>
</table>

Figure 4-9. Air photo characteristics of road surface material
photos and identify any vehicles on the bridge. If you can estimate the load class of the vehicle, you can assume that the class of the bridge is at least the same. If no vehicles are actually on or approaching the bridge, the load class cannot be estimated.

**Step 4.** Identify construction type and materials. On large-scale aerial photography (1:2000 to 1:15,000) such as panchromatic and color, you can easily identify construction type and materials such as masonry, wood, steel-reinforced concrete, and steel by indicators on the photos. These indicators include shadow and photographic tone, color, and texture. With detailed study of the photographs, especially under stereo conditions, you should be able to determine not only the type of construction but also the major structure composition.

**Step 5.** Determine bypass conditions. The standard topographic map will supply all the necessary information to determine bypass conditions for each bridge and LOC structure. However, you must use aerial photography to continuously update the map, particularly under combat conditions. To determine bypass conditions from aerial photography, study the area adjacent to the structure under stereo conditions and note any indications of shallow water, such as sandbars or rocks, that are visible through the water surface. In addition, look for vehicle tracks along the river bank that indicate the location of an existing ford. When the structure is a dam used as a bridge, examine the downstream side of the dam, where the water is often shallow enough to be used as a bypass. Because dams are almost always situated where bedrock is close to the surface, stream bottom conditions are usually firm enough to support most vehicle types.

**Ford Width**

Look for indications that the roadway continues across the channel, such as two faint lines that mark the sides of the traveled way. On some fords, the sides of the roadway are marked by boulders that appear on the imagery. Where the ford has been raised by adding material to the bottom of the stream, the sides may appear as lines of ripples or as eddies of a lighter tone than the surrounding water. Measure the width.

**Ford Bottom Characteristics**

Determining ford bottom characteristics such as paved, rocky, and sandy from aerial photography depends on a number of factors. They include water depth and clarity, film type, and photo scale. To determine this data, orient aerial photos of the ford for stereo viewing using proper procedures. Study the area around the ford, as well as the river or stream channel both upstream and downstream of the ford.

Rapids, white water, and exposed rocks or boulders indicate a rocky bottom. Bars, braiding, and steep banks often indicate coarse-grained material such as sand or gravel. Meanders and oxbows in the immediate vicinity indicate relatively slow-moving streams with fine-grained material. Angular drainage patterns with frequent sharp changes in direction indicate rock control and a rocky bottom. In swift-flowing streams in mountainous areas, fine materials do not settle; therefore, the bottoms are usually rocky or firm.
Length of Ferry Crossing

You can easily determine ferry crossing length from aerial photography if both terminals appear on a single photograph. If two or more photos are required, construct a mosaic of several photos.

Single Photo Method

Determine the scale of the photo, using proper procedures. Locate terminals and measure the open-water distance between terminals with the microcomparator or PI scale. Multiply the measured distance by the denominator of the representative fraction to determine true distance.

Mosaic Method

Determine the number of photos required to cover the entire open-water distance between ferry terminals. Secure the photo containing the most western terminal to a suitable flat surface. Carefully place the adjacent photo over the edge of the first photo, aligning common terrain features of Photo 2 with Photo 1. Continue this process until the second ferry terminal appears on a photo. Check your work, making certain that all photos are properly aligned.

Scale the open-water distance between ferry terminals. Multiply the photo distance by the denominator of the photo representative fraction.

Ferry Terminal Layout

Step 1. Orient the photos for each terminal, using proper procedures, and examine the terminal facilities and approaches.

Step 2. Examine the land facilities. Look for large buildings, parking lots, winches, guy-line towers, and any other features that may affect the use or capacity of the site. When feasible, determine the dimensions of the site and major structures.

Step 3. Examine the water approaches. Look for obstacles, fenders, piers, pilings, and evidence of the channel.

Step 4. Analyze vessel information such as ferry length, beam, and capacity. To do so, you will need to orient photos, locate one or more of the vessels, and determine the photo scale. With the microcomparator, measure the length and width of each vessel. Multiply the photo distances by the denominator of the photo scale to determine true distances.

Step 5. Estimate the number of vessel decks capable of carrying vehicles. Assume an automobile size of 2 by 6 meters and a weight of 2 tons.

Step 6. Estimate vehicle capacity for one deck of the vessel. Multiply this number by the number of decks. If all vessels do not have the same length and beam, measure and record each vessel separately.

Step 7. Examine approach conditions for fords and ferries. Approaches are classified as easy when the slope is 7 percent or less; the surface is relatively smooth with no ruts, potholes, or other obstacles; the width is at least 3 meters; there are no sharp curves within 50 meters of the water’s edge and the surface is well drained.
or free of standing water. Failure to meet all of these conditions will result in the approach being classified as difficult.

**Airfields**

**Step 1.** Using the PI and photographic scales, measure the length and width of the runway. Record the measurements in meters on the factor overlay within the runway boundary lines or beside the runway.

**Step 2.** Determine the surface material of the runway using the information in Table 4-2. Label runways with hard or paved surfaces with a *P*, and loose or unpaved surfaces with a *U*.

<table>
<thead>
<tr>
<th>Type of surface</th>
<th>Surface outlook</th>
<th>Color</th>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sod</td>
<td>Irregular</td>
<td>Brown to green mottled</td>
<td>Tire tracks</td>
</tr>
<tr>
<td>Graded earth, gravel, sand, coral, clay (sources of surfacing material)</td>
<td>May have grader marks</td>
<td>Light to dark color, mottled</td>
<td>Open pits in the vicinity</td>
</tr>
<tr>
<td>Pierced metal</td>
<td>Grid pattern</td>
<td>Brown to green, mottled</td>
<td>Piles of plank in area</td>
</tr>
<tr>
<td>Concrete</td>
<td>Smooth, surface may be patched or painted</td>
<td>Light gray to white, uniform</td>
<td>Block pattern</td>
</tr>
<tr>
<td>Asphalt</td>
<td>Smooth, surface may be patched or painted</td>
<td>Very dark to light gray, usually uniform</td>
<td>None</td>
</tr>
</tbody>
</table>

Table 4-2. Airfield surface materials information

**Railroads**

**Step 1.** From the stereo pairs, locate the area of the railroad to analyze. Compare the date of the photographs with the date of the last map revision or update. If the photographs are more recent than the map, use them. If the map is more recent, give greater weight to the map information however, even if it is more recent, it should not always take precedence over the photographs, because map information is often general. As a result, some feature such as sidings are not shown.

**Step 2.** Look for any railroad sidings not shown on the map. Compare the outline of all built-up areas on the photos with the map symbols of the same areas. Lightly sketch any new alignments or built-up areas onto the overlay in pencil.

**Step 3.** Verify the location of each segment end point. If the end points determined from the photo differ from those obtained from the map, use the points obtained from the photos. Relocate the endpoint symbols on the overlay, renumber the segments if necessary, and determine the coordinates of the relocated points. Change entries in the railroad data tables if necessary.
Step 4. Verify the gradient of each segment that has a grade of 3 percent or greater.

Step 5. Examine aerial photography to verify the location of culverts or streams. The map indicates the location of culverts or streams passing beneath the railroad. Also check all areas on the photos where a stream or drainageway intersects a railway. If these areas indicate culverts, annotate the overlay at each location. Make notes in the data tables as necessary.

Step 6. Locate built-up areas on aerial photos that show railway through-routes. Locate any zones where buildings, walls, and so forth constrict the width of the route to less than 4 meters. Measure the constrictions, using the microcomparator or the PI scale, and record the data in the proper place on the overlay.

Step 7. Examine and verify areas previously identified as level crossings. Make additions, deletions, or changes on the overlay as required.

Step 8. Determine catenary clearance. The clearance beneath the catenary is required only if the railroad understudy is electrified and uses overhead wires. The catenary clearance is seldom shown on maps. Photos may provide some indication of catenary clearance. If not, place a question mark above the crossings on the overlay to indicate there are overhead wires but the clearance is unknown.

Step 9. Assemble the vertical photos that provide stereo coverage for each bridge recorded on the factor overlay. If oblique photos are available, place them with the vertical ones. Study the material carefully to become familiar with the general characteristics of the bridge. Determine the number of spans, overhead clearance, and so forth. Measure the roadbed widths. Record all data in Railroad Date Table 2 or annotate it on the overlay.

Inland Waterways

Classify inland waterways according to their depths. Very shallow waterways have depths less than 1.4 meters. Medium waterways have depths between 1.4 and 2 meters. Deep waterways have depths greater than 2 meters. See Chapter 2 for more information.

Facilities and Installations

Step 1. Identify all wharves. Figure 4-10 shows a reference diagram of a wharf.

Step 2. Identify all locks. Common types of leeks are single and multiple-chamber. See Figure 4-11. Gates are the most vulnerable features of a leek. Common types of gates are:

- Double-leaf miter gates (see Figure 4-12). A pair of hinged gates that form a V or angle across the end of the leek when closed. The apex is always upstream to use the head of water to keep the gates closed.
- Single-leaf miter gates. Hinged gates that pivot into a recess in the lock wall. See Figure 4-13.
- Vertical-lift gates. Lock gates that move in a vertical plane. Those gates are usually suspended from an overhead frame and counterbalanced.
Caisson or sliding (retractile) gates. Those gates move horizontally into wells or caissons when open.

Segmental gates. A pair of gates shaped like sectors of a cylinder. They are hinged at the sides and rotate into wells.

Step 3. Prepare final overlay. See Chapter 8 for procedures.
PART TWO  Analysis Procedures  FM 5-33

URBAN AREAS

Step 1. Obtain a 1:50,000-scale map covering the area of interest. Register the mylar to the map or data base and annotate the marginal information. Then locate and outline all areas that cover the area to be studied.

Step 2. Establish a numerical priority listing (ranking) of urban areas to be analyzed at a scale of 1:12,500. Determine this sequence based on whether the areas are administrative centers (state and national capitals, strategic centers of

![Diagram of locks]

**Figure 4-11. Types of locks**
production, steel, manufacturing, and nuclear power plants), or are located on dominant ground or on major avenues of approach.

**Step 3.** Assign a priority number to each urban area and carry out the analysis accordingly. Where all urban areas on a 1:50,000-scale map are to be analyzed without concern for priority consideration, number each area, beginning at the top left corner of the identification overlay, and proceed across and down the map.

**Step 4.** Retrieve a 1:12,500-scale topographic map of the urban area. If you cannot find any, outline the desired area on the 1:50,000-scale map and enlarge this map segment by 400 percent. If a 1:25,000-scale map is available, you may enlarge
You will require multiple overlays to extract information for the data fields documented in order to map adequately the diverse terrain features that makeup the urban area. In this regard, the number of overlays to be used is considerably greater than the number used in other areas. Some topics include vegetation, roads and related structures, drainage and water resources, and railroads and related structures. Because of the larger scale of the urban-mea products and the complexities inherent in this unique terrain, some elements are portrayed differently from those depicted on overlays keyed to 1:50,000-scale maps.

**Step 5.** Determine the area to be analyzed and gather all necessary aerial photographs in stereo pairs to cover the area. Orient them for stereo viewing.

**Step 6.** View the photographs in stereo and use the PI keys and text to determine the urban type in the aerial coverage. Then analyze, outline, and identify all types and label them with the appropriate urban code.

**Step 7.** Determine the roof coverage. Density refers to the ratio of roof area of buildings to total ground area, including streets and small open spaces. To determine roof cover percentage from aerial photography, collect the necessary stereo pairs for the area to be analyzed and note the photo scale. Measure the footage of the area, both the length and width, with a thousands-foot scale and multiply it by the photo scale.

\[
GD = PD \times PSR
\]
\[
Area = L \times W
\]

Where--

GD = ground distance
PD = photo distance
PSR = photo scale reciprocal
L = length
W = width

**Step 8.** Determine the roof size by measuring the average roof in the area the roofs should all be about the same size. Using the microcomparator, measure the length and width of an average roof and multiply it by the photo scale. Then count the number of buildings and multiply that number by the area of the roofs. To determine the percentage of the roof coverage, take the roof size times the number of buildings in the area, divide it by the total area, and multiply it by 100.

\[
\text{Total area of buildings x Number of buildings in area \times 100} = \% \text{ Roof coverage}
\]

\[
\text{Total area size}
\]

Figure 4-13 will help determine the percentage of roof coverage and the percentage of concealment from aerial detection. Use the appropriate symbol to mark the overlay.
Step 9. Determine construction and building type. Make appropriate annotations for type of construction or building, using the definitions below. Note: Building types 5 through 8 are comprised of multistory office and apartment buildings. For the purpose of classification and subsequent evaluation, each category is divided into low-rise buildings of six stories or less and high-rise structures in excess of six stories.

- **Type 1.** Wood and timber frame construction. Most farm buildings and those buildings constructed prior to the late 19th century are classified as Type 1. Their ceilings with wooden rafters and weak exterior walls offer little protection from indirect or direct weapons fire. Internal communications routes are excellent since their lightly constructed walls are easy to breach; however, significant reinforcement is required to provide protective cover if such buildings are to be used as defensive positions. Within larger built-up areas, Type 1 buildings present the greatest fire hazard. See Figure 4-14.

- **Type 2.** Masonry construction. Buildings with strong walls of brick or natural stone constructed in the 19th and early 20th centuries are classified as Type 2. These buildings, typified by the old town hall, are commonly found in the central areas of towns and cities. They generally contain from two to four stories with ceilings with wooden rafters and tightly constructed tile roofs. Presenting less of a fire hazard than wood and timber frame structures, Type 2 buildings are frequently suitable as defensive positions. While internal communication routes are excellent, external walls are difficult to breach without heavy weapons or demolitions. See Figure 4-14.
Type 3. One- or two-family dwellings. Family dwellings constructed of solid or insulating bricks or of cinder blocks with ceilings of reinforced concrete are classified as Type 3. Such buildings frequently contain strongly constructed basements. Type 3 buildings offer significant protection and require little reinforcement if used as defensive positions. Because of Type 3 construction, fire hazards are minimal. If demolished, significant rubble is generated, offering protection to the defender or creating an obstacle to the attacker. See Figure 4-15.

Figure 4-14. Examples of construction/building type (wood and frame and masonry)

Figure 4-15. Example of construction/building type (family dwellings)
Type 4. Prefabricated one-family dwellings. Prefabricated family dwellings assembled with precast and light building materials are classified as Type 4. In most cases, the cellars or basements are strongly constructed. Unlike Type 3 dwellings, these buildings require significant reinforcement if they are to be used as defensive positions. They also constitute a fire hazard in a freed defense. Rubble produced by their destruction creates an effective obstacle and additional cover for ground-level defensive positions. See Figure 4-13.

Type 5. Low-rise office buildings. Multistory office buildings, with their steel frame and reinforced concrete construction, are normally characterized by large expanses of plate glass which offer little protection. See Figure 4-16.

Type 6. High-rise office buildings. These buildings are also characterized by large expanses of plate glass which offer little protection, but they have six stories or more.

Type 7. Low-rise apartment buildings. While similar in size to low-rise office buildings, they generally have smaller glass areas and load-bearing reinforced concrete exterior walls which provide greater protection.

Type 8. High-rise apartment buildings. See Type 4, paragraph 2. See Figure 4-16.

Type 9. Buildings common to newer industrial and warehouse complexes are classified as Type 9. While the type construction may vary considerably, steel framing and the use of lightweight materials for exterior walls and roofs are normal practices. Reinforced concrete floors and ceilings are frequently used in multistory buildings.

Figures 4-17 through 4-31 show examples of industrial areas that will be useful in identifying specific subdivisions of the industrial classification.

This completes the urban analysis procedure. See Chapter 8 for final overlay preparation procedures.
Figure 4-16. Example of construction/building types (multistory buildings)

Figure 4-17. Example of a construction/building type
(thermal electric power plant)
Figure 4-18. Example of construction/building type (penstock type hydroelectric power system)

Figure 4-19. Example for construction/building type (low dam type hydroelectric power system)
Figure 4-20. Example of construction/building type (high dam type hydroelectric power plant system)

Figure 4-21. Example of construction/building type (thermal nuclear power plant)
Figure 4-22. Example of construction/building type (internal combustion power plant)

Figure 4-23. Example of construction/building type (ore processing - benefication)
Figure 4-24. Example of construction/building (ore processing - magnesia from brines)

Figure 4-25. Example of construction/building
(ore processing - reduction - classical smelter)
Figure 4-26. Example of construction/building  
(ore processing - reduction - horizontal retort smelter)

Figure 4-27. Example of construction/building  
(ore processing - reduction - horizontal retort smelter)
Figure 4-28. Example of construction/building type (electrolite recovery)

Figure 4-29. Example of construction/building type (master flowchart of the petroleum industry)
Figure 4-30. Example of construction/building type (ore processing - bayer alumina)

Figure 4-31. Example of construction/building type (integrated iron and steel plant)